Nature Conservation 42: 33–49 (2020)
doi: 10.3897/natureconservation.42.48314
https://natureconservation.pensoft.net

CONSERVATION IN PRACTICE

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Nature Conservation
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Does public information about wolf (*Canis lupus*) movements decrease wolf attacks on hunting dogs (*C. familiaris*)?

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Academic editor: A. Grimm-Seyfarth | Received 8 November 2019 | Accepted 7 October 2020 | Published 23 October 2020

http://zoobank.org/0BFCC7A7-2E9C-4FFA-89F8-B893049F5A0B

Citation: Tikkunen M, Kojola I (2020) Does public information about wolf (*Canis lupus*) movements decrease wolf attacks on hunting dogs (*C. familiaris*)? Nature Conservation 42: 33–49. https://doi.org/10.3897/natureconservation.42.48314

Abstract

The threat that wolves (*Canis lupus*) pose to hunting dogs is one reason why Finnish hunters have negative attitudes towards wolves and one of the potential motivations for the illegal killing of wolves. During 2010–2017, wolves killed an average of 38 dogs (range 24–50) per year in Finland. Most of the attacks (91%) were directed at hunting dogs during the hunting season. To decrease the risk of attacks, the last seven positions (one position per hour) of GPS-collared wolves were accessible to the public with a 5 × 5 km resolution during the hunting seasons (from August 20th to February 28th) of 2013/2014 (from September 2nd onwards), 2015/2016, 2016/2017 and 2017/2018. The link was visited more than 1 million times in 3 of the 4 seasons. Fatal attacks on dogs occurred on 17% of the days during the hunting seasons of our study (n = 760 days). Both the attacks and visits peaked in September–November, which is the primary hunting season in Finland. According to the general linear model, the number of daily visits to the website was higher on days when fatal attacks occurred than on other days. Additionally, season and the number of days passed from the first day of the season were significantly related to the daily visits. Visits were temporally auto-correlated, and the parameter values in the model where the dependent variable was the number of visits on the next day were only slightly different from those in the first model. A two-way interaction between season and attack existed, and the least squares means were significantly different in 2017/2018. The change in daily visits between consecutive days was related only to the number of days from the beginning of the season. We examined whether this kind of service decreased dog attacks by wolves. Wolf attacks were recorded in 32% of the wolf territories, where at least one wolf had been collared (n = 22). However, within the territories without any GPS-collared wolves, the proportion

of territories with wolf attack(s) was significantly higher than those elsewhere (50%, n = 48). Although public information decreased the risk of attacks, it did not completely protect dogs from wolf attacks and may in some cases increase the risk of illegally killing wolves. The most remarkable benefit of this kind of service to the conservation of the wolf population might be the message to the public that management is not overlooking hunters' concerns about wolf attacks on their dogs.

Keywords
Attacks, *Canis lupus*, *Canis familiaris*, GPS, hunting dogs, risk, territory

Introduction

Large carnivores and humans are often in conflict due to carnivore damage to livestock (Ciucci and Boitani 1998; Dahle et al. 1998; Kaczensky 1999; Madhusudan and Karanth 2002; Treves et al. 2002; Madhusudan 2003; Musiani et al. 2003; Polisar and Eisenberg 2003; Gunther et al. 2004; Frank et al. 2006; Iliopoulos et al. 2009; Inskip and Zimmermann 2009; Olson et al. 2015a; Montalvo et al. 2016). Wolves (*Canis lupus*) also kill domestic dogs (*Canis familiaris*) (Ciucci and Boitani 1998; Bangs and Shivik 2001; Kojola and Kuittinen 2002; Fritts et al. 2003).

Damage from large carnivores often generates displeasure and frustration (Bisi and Kurki 2008) and may fuel the illegal killing of carnivores (Liberg et al. 2012; Pohja-Mykrä and Kurki 2014; Olson et al. 2015b; Suutarinen and Kojola 2017). Illegal killing has been very influential, e.g., on Nordic wolf populations (Jansson et al. 2012; Liberg et al. 2012; Suutarinen and Kojola 2017).

Conflict between humans and large carnivores was absent in Europe and North America when large carnivores were almost extinct in the nineteenth and early to mid-twentieth centuries because of intense persecution, prey extermination and habitat conversion (Breitenmoser 1998; Linnell et al. 2009). With increased environmental awareness, protection, including better hunting management, reintroductions and habitat recovery after abandonment, wolves, bears and Eurasian lynxes experienced a continent-wide recovery in the first half of the twentieth century, which has led to conflicts in many countries in Europe and North America (Breitenmoser 1998; Chapron et al. 2014).

The present-day hunting culture in Scandinavia and Finland is highly dependent on dogs (Bisi et al. 2010). In Finland, hunters hunt small game such as small deer (*Cervidae* spp.) and hare (*Lepus timidus*), game birds such as grouse, waterfowl, and big game animals, mostly moose (*Alces alces*) and brown bear (*Ursus arctos*). The most popular big game animal is moose. In 2019, half of the Finnish 200 000 hunters participated in moose hunting (Natural Resource Institute Finland 2020).

Following the return of wolves in the 1980s, wolf attacks on hunting dogs (*Canis familiaris*) have led to conflicts between wolves and hunters, especially in Sweden and Finland (Kojola and Kuittinen 2002; Kojola et al. 2004b; Backeryd 2007; Bisi et al. 2007; Peltola and Heikkilä 2015), where the current dog-assisted hunting culture developed during an era without wolves (Bisi et al. 2007). In Finland, wolves kill an

average of 38 dogs (range 24–50) per year. Over 90% of the attacks are on hunting dogs during the hunting season. Additionally, in the Great Lakes area in the USA and Scandinavia, dogs used for hunting are killed more often than are pet dogs (Backeryd 2007; Ruid et al. 2009; Edge et al. 2011; Olson et al. 2015a).

Specifically in Finland, moose hunting with dogs is popular, and its significance has made wolf depredation of hunting dogs even more serious than elsewhere in the world (Bisi et al. 2010). Wolves also compete with humans by preying on moose, which increases conflict (Wikenros 2011). One aspect of conflict is that the status of wolves is regulated by the EU Habitats Directive, which requires member states to establish a system of strict protection for wolves. After Finland joined the EU in 1995, the management of the wolf population has not been in the hands of the local people, and this scenario has also increased conflict (Bisi et al. 2007). Before EU membership, Finland could independently define its wolf policy. The wolf is still listed as a game species, and the population has been controlled by license-based hunting.

Although dog owners receive compensation from the Ministry of Agriculture and Forestry of Finland for wolf-killed dogs, the risk of losing a well-trained, valuable hunting dog to a wolf generates frustration among hunters and might even provoke some hunters to illegally kill wolves (Bisi et al. 2010; Liberg et al. 2012; Pohja-Mykrä and Kurki 2014; von Essen et al. 2014). In 2019, the Ministry of Agriculture and Forestry of Finland paid 160 000 euros in compensation for dogs attacked by wolves. The highest sums compensated for one dog have been approximately 10 000 euros (Ministry of Agriculture and Forestry of Finland 2020). Even if the loss of a dog is compensated for, compensation programs alone are not effective in reducing conflict or preventing poaching (Ciucci and Boitani 1998).

Wolf attacks on dogs also influence public opinion about wolves, which affects wolf conservation in Finland. Hunting dog conflicts, in particular, have been considered one of the most difficult issues in Finnish wolf policy, and resolving the conflict would contribute positively to the wolf policy (Peltola and Heikkilä 2015). Public opinion can influence the management policies of large carnivores (Wolch et al. 1997; Bisi et al. 2010; Olson et al. 2015a). Public opinion can become more positive towards wolves following quick responses to wolf conflicts (Ruid et al. 2009). In Finland, negative attitudes towards wolves were one of the reasons why the Finnish authorities allowed regulated hunting of wolves in 2015 and 2016 (The Finnish Wildlife Agency 2015). Hunters influence the moose population in Finland, which makes the management of both moose and wolves even more complicated.

Preventing wolf attacks on hunting dogs may lead to an increased acceptance of wolves, which is a key factor in protecting the population of Finnish wolves (ca. 200 wolves in 2019; Ministry of Agriculture and Forestry of Finland 2019). The number of wolves has fluctuated between 120 and 245 wolves since 2013. The wolf population has not reached the level of 25 breeding couples, the definition of a viable population (Ministry of Agriculture and Forestry of Finland 2019). On the IUCN Red list, the wolf is globally considered a 'least concern' species, but nationally, in Finland, it is classified as endangered (Hyvärinen et al. 2019).

Hunters' attitudes matter in the conservation of wolves in Finland (Bisi et al. 2007; Bisi et al. 2010). Effective and hunter-accepted ways to protect hunting dogs from wolves do not exist. Among most of the popular hunting methods used for terrestrial games, such as the mountain hare and especially moose, the dog is typically isolated and relatively far from the hunter when chasing game. This scenario makes it very challenging for the hunter to intervene during a wolf attack (Olson et al. 2015a). Ruid et al. (2009) found that attacks on hunting dogs generally occurred while hunters were ≥200 m away. In Finland, hunters use global positioning system (GPS) tracking for hunting dogs, which allows tracking over long distances (Paldanius et al. 2011). This approach may also increase the response time of hunters to a conflict, allowing them to determine that a problem has arisen and respond to that problem more quickly than with traditional VHF tracking systems. However, hunting dogs are exposed to many other risks when hunting. For example, vehicle collisions and shooting accidents kill or injure more hunting dogs than wolves in Sweden (Agria 2019).

Hunters can avoid releasing a dog if they find fresh wolf tracks on their hunting grounds, but this precaution can usually only be implemented when the ground is covered by snow. Harnesses and other means that protect dogs from wolf bites can be functional (Fedderwitz 2010), but they do not prevent dogs from being attacked. Even if the attacked dog survives, it might refuse to participate in hunting anymore (Tallavaara 2007). Therefore, it is important to develop methods that prevent wolf attacks on hunting dogs.

In this study, we examined the seasonal use of publicly accessible, online wolf location data with a 5×5 km resolution and evaluated the effectiveness of this kind of service in preventing wolf attacks on hunting dogs. We hypothesized that as the number of attacks increases, the number of visits to the publicly accessible website increases accordingly and that as the number of collared wolves available for the public to monitor increases, the website will be visited more. Furthermore, we predicted that wolf attacks on dogs will be fewer in territories with one or more collared wolf.

Methods

Study areas

We analysed daily visits to the public website (http://riistahavainnot.fi/suurpedot/havaintokartta; see below) as a daily sum from Finland because it is forbidden by law to reveal the locations of the visitors on the website. A territory-specific study of wolf attacks was carried out in eastern Central Finland (Fig. 1). This area contains three counties: Kainuu, Northern Savo and North Carelia. The area covers a total of 66 401 km^2 (National land Survey of Finland 2016). The population is approximately 484 000. The density of the population varies from 3.58 citizens/km in Kainuu to 10 citizens/km in North Carelia and 15 citizens/km in Northern Savo (Statistics Finland 2019). In every county, the population lives in large cities, and in rural areas, the population is sparse.

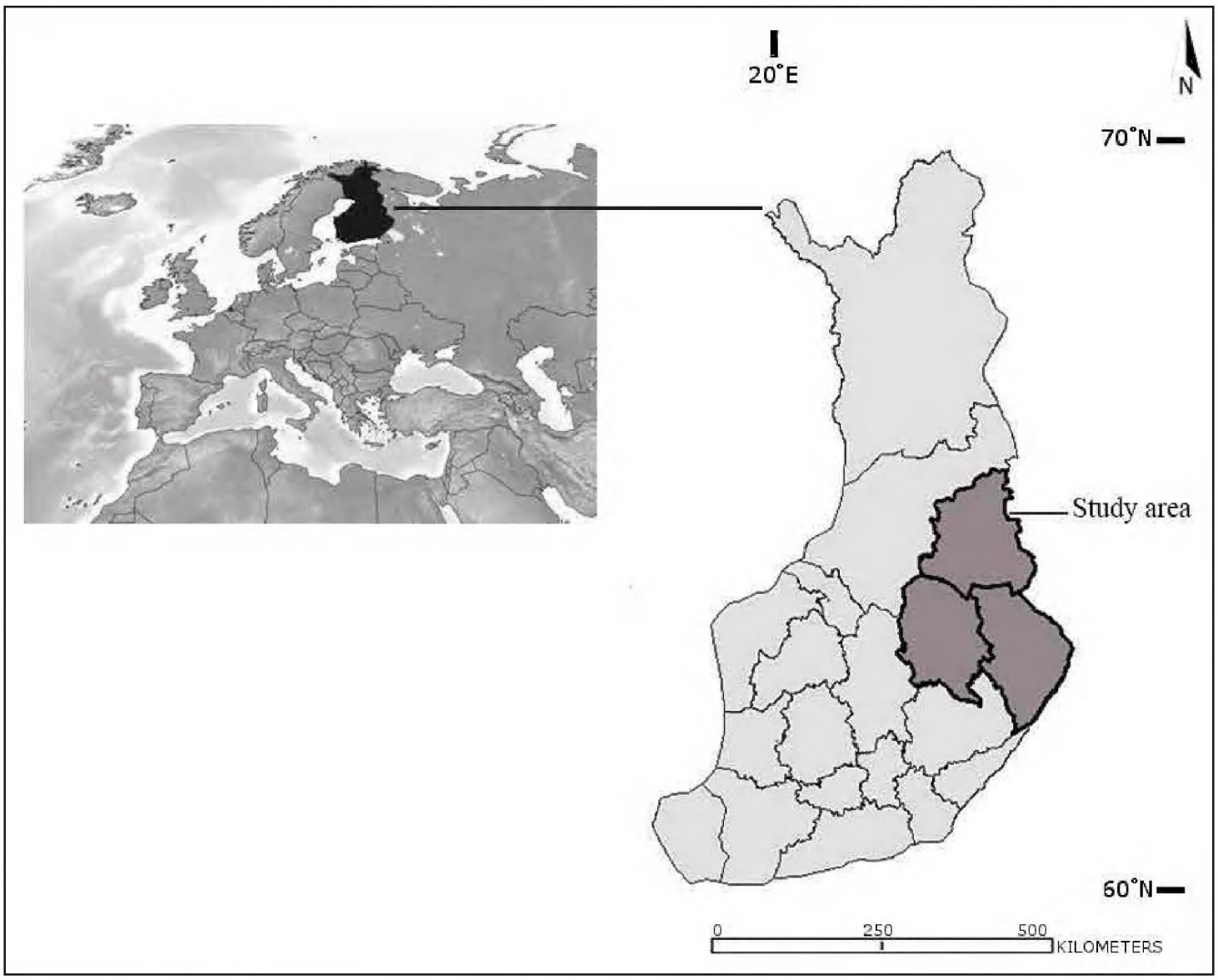

Figure 1. The study area encompassed three provinces: Kainuu, Northern Savo and North Carelia, in eastern Finland.

The study area contains mainly coniferous boreal forest, and the predominant tree species are Scotch pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*) mixed with birches (*Betula pendula* and *B. pubescens*) and some other deciduous trees. The forests are commercially exploited, and therefore, young stands and clear cuts are common. The area is covered by a dense network of timber roads that are mostly accessible to everyone and driveable by car, except in the winter. Permanent winter snow usually appears in November and melts in late April or early May.

Moose is the primary prey species of the wolves in our study area (Gade-Jorgensen and Stagegaard 2000; Kojola et al. 2004a). Moose may constitute >90% of the biomass ingested by wolves (Gade-Jorgensen and Stagegaard 2000). The density of moose is 0.2–0.4 animals/km^2 (Natural Resources Institute Finland 2019a). There is a small population (approximately 700) of wild forest reindeer (*Rangifer tarandus fennicus*) in a 10 000 km^2 area in the Kainuu region in eastern Finland, but these reindeer constitute far less of the wolves' diet than moose in that region (20–50%; Kojola et al. 2004a). In addition to wild ungulates, wolves prey on smaller mammals (e.g., hare), which constitute 20–30% of the diets of the wolves (Kojola et al. 2004a).

Between 2013 and 2017, the Finnish wolf population was concentrated in eastern Finland (~50–60% of the population); however, in 2018, the population started to

spread to southern Finland, and only ~30% lived in eastern Finland (Natural Resources Institute Finland 2019c). The population has fluctuated over the study years. In 2015 and 2016, the population decreased due to the regulated hunting of wolves, which resulted in the killing of 70 individuals, with a combined known mortality of 120 wolves in 2015 and 2016 (Ministry of Agriculture and Forestry of Finland 2020).

Collared wolves

In our study period, 2013 and 2015–2017, wolves were captured by the Natural Resources Institute of Finland in February–April, mostly by darting them from a helicopter (see Kojola et al. 2016). A few wolves were captured using an armed lasso from a snowmobile. The detailed protocols of the capture and immobilization procedures are given elsewhere (Kojola et al. 2006; Wabakken et al. 2007). Between 2013 and 2017, there were 33 collared wolves at the beginning of the hunting season (August 20th). No wolves were collared in 2014, and therefore, the hunting season of 2014/2015 was excluded from the analyses.

The wolves were collared with transmitters containing a GPS and a global system for mobile communications (GSM) to obtain their locations (Vectronic Aerospace, Berlin, Germany). Capturing, handling, and anaesthetizing the wolves were performed according to the guidelines issued by the Animal Care and Use Committee at the University of Oulu and the permit provided by the National Animal Experiment Board. Collars must receive a signal from at least three satellites to obtain an exact location. The interval between subsequent attempts was one hour, and the collar sent a bundle of locations after it had stored seven locations.

We used the data from only one collared wolf per pack for the following analyses. The movements of one wolf were representative of the movements of the whole pack because each wolf pack moves mostly as one unit in the autumn and winter (Okarma et al. 1998; Mech and Boitani 2003).

The mean 100% kernel territory size for the GPS-collared wolves (n = 22) during the autumn and winter hunting season (from August 20th to February 28th) in eastern Central Finland (Fig. 1) was 1 137 km^2 (range 457 km^2 –1 700 km^2, SE 117, 35), which we used as an approximation of the territory size for the uncollared wolves. Because the shape of the territories without collared wolves was not known for 2013 and 2015, we used circular wolf territories with a radius of 19 km, which is the radius of the 1 137 km^2 home range.

The midpoints of such territories were estimated using point observations provided by a network of large carnivore contact persons (ca. 2 000 people; Kojola et al. 2018) who record wolf observations and input the data into a digital large carnivore observation system, specifying the observation type (sighting, track, prey kill site, or livestock depredation), date, geographic location, age, status, number of animals, and front paw-print dimensions. Contact persons are nominated by local game management associations and are educated about the biology, ecology and movement behaviour of wolves and footprint identification (Kojola et al. 2018). Core wolf territory areas were estimated based on the location of the point observations (Kojola et al. 2018).

For the 2016/2017 and 2017/2018 seasons, the polygons for the territories of wolves without collars were evaluated using volunteer-provided point observations and genetic monitoring by professionals (Kojola et al. 2018). In total, there were 48 territories within the study area in eastern Finland (Fig. 1) occupied by uncollared wolves.

In our study area in eastern Finland, we considered only the attacks that took place during GPS tracking or those when we could be sure that the territory was occupied by collared wolves when the attack occurred. For example, if there was a gap in the GPS signal, then we assumed that the territory was still occupied by the same wolves as those before the gap. With the uncollared wolves, we used the whole hunting season as a reference period. If we could not be sure whether the attack had taken place in a territory occupied by collared or uncollared wolves, then we did not include the case in the analyses.

Wolf attacks

The Ministry of Agriculture and Forestry of Finland and officials of municipalities provided data on wolf attacks on hunting dogs. Not all attacks are reported to the ministry because dog owners did not apply for compensation. Each attack was counted once, and overlaps were deleted. In total, 55 attacks took place within the territories in the study area in eastern Finland.

Public website

The website link (http://riistahavainnot.fi/suurpedot/havaintokartta) was active throughout the main hunting season (from August 20th to February 28th), showing the last locations of the collared wolves with a 5×5 km accuracy. The website is maintained by the Natural Resources Institute of Finland, which also collars the wolves with funding from the Ministry of Agriculture and Forestry of Finland. The website also includes information about the wolf territories in Finland, dispersing wolves, and wolf observations that citizens have recorded.

In Finland, allocation information on collared wolves has been released to the public during hunting seasons since 2013. Some wolves (n = 5) were collared more than once, but we only considered the last year of monitoring when considering how many of them survived through the hunting season.

Statistical analyses

We performed a general linear model (GLM) analysis to test whether the number of daily visits to the webpage was related to the occurrence of fatal attacks on (1) the previous day or (2) the same day and the number of GPS collared wolves, season, and the days passed from the beginning of the season. Because visitors to the webpage may become more reactive to the known attacks, we tested two-way interactions between season and the occurrence of attacks on the number of daily attacks. Then, we examined whether attacks increased with the number of visits via a GLM, where the change in

visits between consecutive days was related to the number of attacks, season, and days passed from the beginning of the season. To evaluate the effects of the public webpage on the risk of attack, we performed a non-parametric Chi-square test to compare the distribution of territories of collared and uncollared wolves, with and without attacks. The analyses were conducted with SPSS for Windows version 24.0, using a significance value of 0.05.

Results

The website providing information about the locations of the GPS collared wolves was first published for the 2013/2014 hunting season when the site was visited almost two million times. The visits were not that frequent in 2015/2016 (<million), which followed the season when no wolves had an active transmitter, but in the following hunting seasons of 2016/2017 and 2017/2018, the number of visitors was over a million.

The number of visits to the webpage was high during the day when the link was opened, probably owing to the media release announcing the opening of the service. The overall pattern of daily visits in 2013/2014 and 2015/2016 was a gradual decrease across the season, while in 2016/2017 and 2017/2018, a peak in visits occurred between the 50th and 100th days from the opening of the service (Fig. 2), which was temporally consistent with the first weeks of moose hunting.

At least one fatal wolf attack on dogs was recorded on 17% of the days (n = 760) we monitored during this study. In 4% of the cases, there was also an attack on the next day. The number of daily visits was positively related to the recent occurrence of fatal attacks by wolves on dogs during the hunting season, the number of wolves with an active collar, and the number of days passed from the day when the link was opened (Table 1). The daily visits were temporally auto-correlated, and therefore, having the number of visits in the day following the attack as the dependent variable provided results that were only slightly different from those of the first model (Table 1). This model also included the cases (27 of 129) where at least one attack had taken place on both the previous day and the same day. In a model where only these particular cases were denoted positive and the others negative, statistically significant differences in the number of visits did not exist.

The two-way interaction term between hunting season and the number of daily visits was significant (Table 1), providing evidence that the relationship between attacks and visits varied by season. Least squares means differed only for the last hunting season (2017/2018).

The mean number of days that wolf-specific public information was available was 168 days (range 38–193). The large variation was due to wolf mortalities and technical flaws in the transmitters. The locations of 22 collared wolves were still publicly available after the hunting season ended (February 28th). Of the remaining 11 wolves, six wolves were killed as a result of permitted hunting or other killing, two wolves were

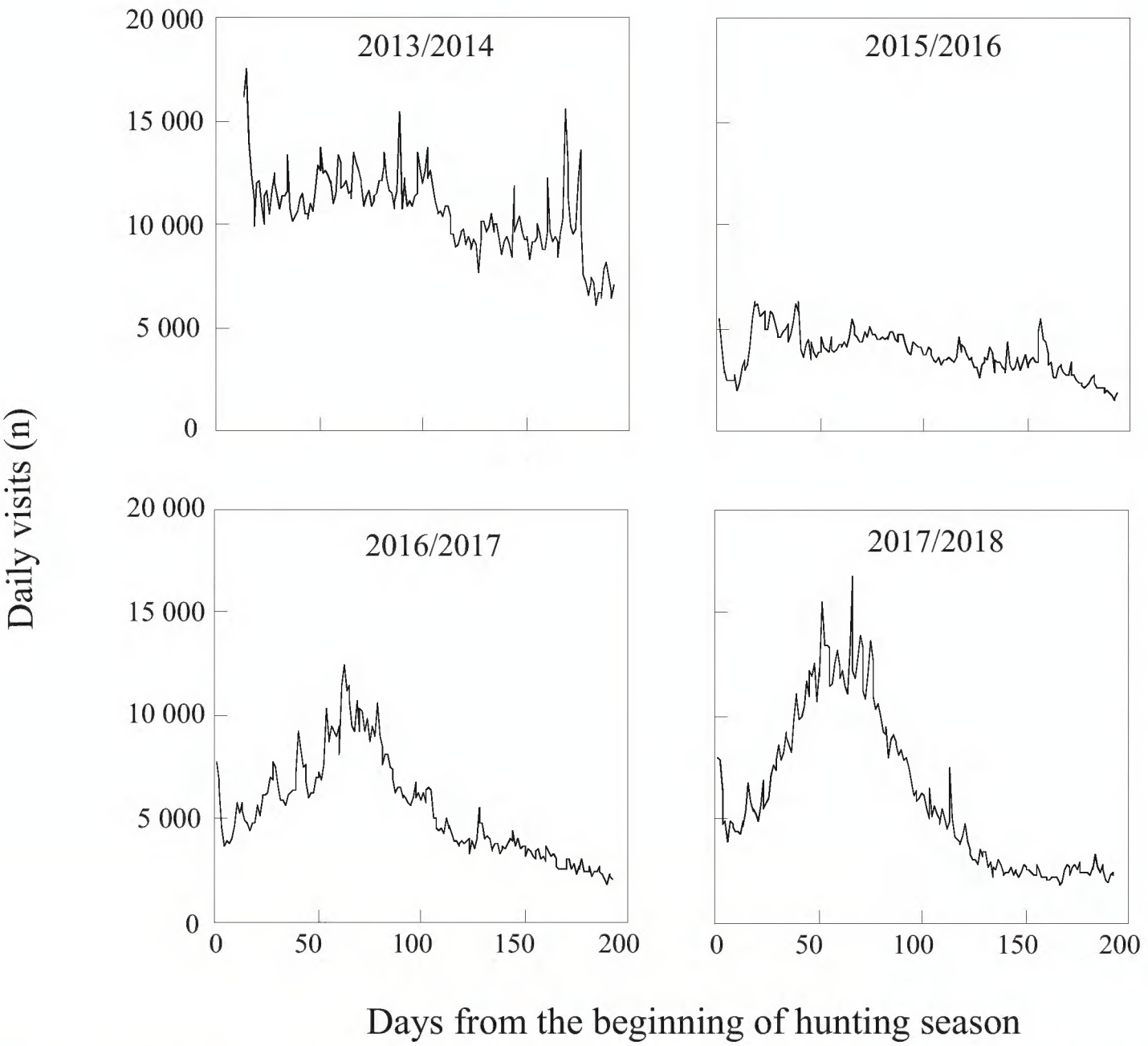

Figure 2. Daily visits to the publicly accessible website showing wolf location information during the hunting seasons (from August 20th to February 28th, in 2013 the website was opened on September 2nd).

found dead (reasons for death unknown), and three wolves were lost during monitoring because the collars stopped working. Considering poaching, it is possible that the wolves that were lost during monitoring or were found dead (5 of 33) were illegally killed. Suutarinen and Kojola (2017) reported that illegal killing was the main cause of mortality in collared wolves (40%); however, the number of possibly illegally killed wolves in this study was relatively low (15%). The time of disappearance or possible death was between October 23th and January 31th. None of the wolves disappeared or were found dead after a dog attack.

In eastern Finland, the proportion of the territories where the attacks took place was higher in the territories without any GPS-collared wolves (50%, n = 48) than that in the territories with at least one collared wolf (32%, n = 22, chi-square for difference = 7.86; $p = 0.005$; n = 48, Fig. 3). There were 0.59 attacks per territory with at least one collared wolf and 0.88 attacks per territory without any collared wolves.

Table 1. General linear model for the number of daily visits to the public webpage providing information about positions of GPS collared wolves at a 5×5 km resolution during four hunting seasons in Finland. Wolf attack (no or yes) and hunting season (2013, 2015, 2016, or 2017) were treated as categorical variables.

Dependent variable	Independent variable	Level	Coefficient	F	P	Adj. R^2
Visits in the same day	**Constant**		-1 668.51			
	Wolf attack	0	-223.44	5.44	0.020	
	Hunting season	2013	-1 114.33	58.13	< 0.001	
		2015	-1 186.20			
		2016	2 618.60			
	Number of collared wolves		1 806.28	56.37	< 0.001	
	Days from the season's 1st day		-8.44	10.85	0.001	
	Hunting season*attack	0*2013	248.08	9.10	< 0.001	
		0*2015	301.29			
		0*2016	268.15			
						0.709
Visits on the next day	**Constant**		-2 664.20			
	Wolf attack	0	-252.44	6.89	0.009	
	Hunting season	2013	-1 535.99	59.10	< 0.001	
		2015	-1 016.72			
		2016	2 947.91			
	Number of collared wolves		1 183.34	66.61	< 0.001	
	Days from the season's 1st day		-6.92	7.28	0.007	
	Season*attack	0*2013	175.83	7.92	< 0.001	
		0*2015	277.53			
		0*2016	299.13			
						0.710

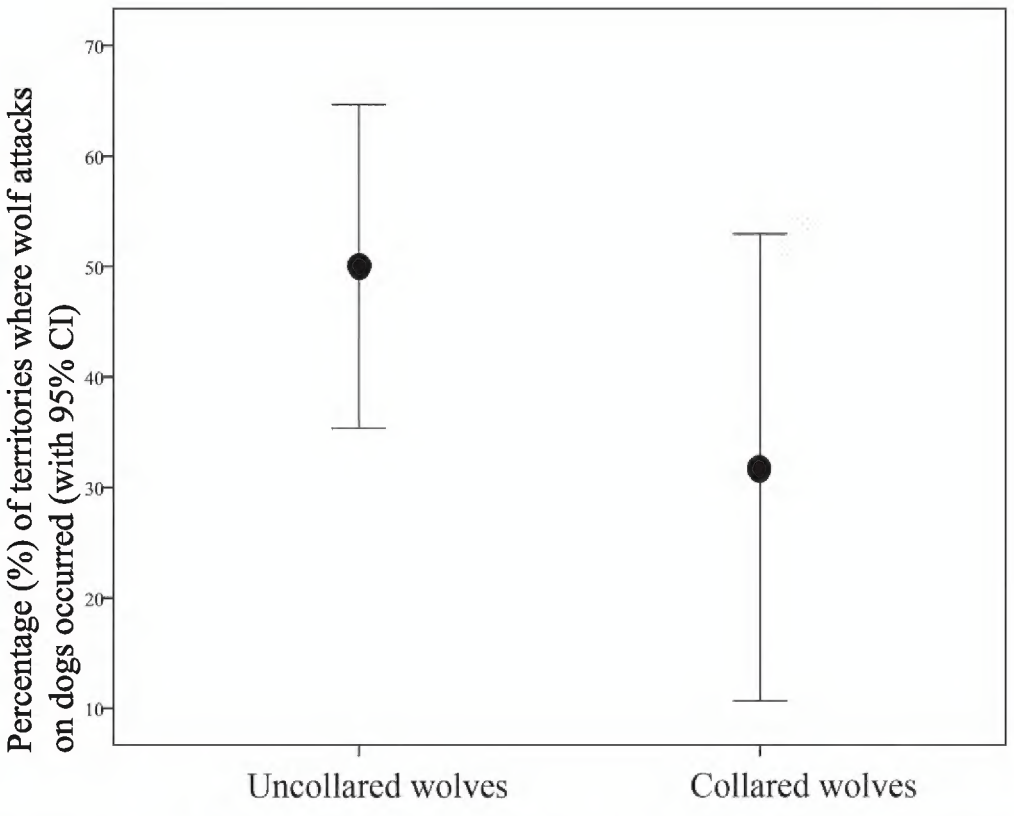

Figure 3. Percentages (%) of the territories in eastern Finland during the hunting seasons of 2013/2014 and 2015/2016–2017/2018 where wolf attacks on dogs occurred, including the mean numbers and 95% confidence intervals of the territories with and without collared wolves that had wolf attacks. As we predicted, the proportion of territories where attacks occurred was higher in territories where none of the wolves have a collar than in other territories (chi-square for difference = 7.86; p = 0.005; n = 48) (n = 22 for collared wolves, n = 48 for uncollared wolves).

Discussion

Public wolf location information was very popular. In the first hunting season when the service was available (2013/2014), the number of visits to the website was 2 million. Our results provided evidence that temporary and recent wolf location information might decrease the risk of attacks on hunting dogs. However, this protective measure has many limitations. The measure is expensive and cannot provide full protection from wolf attacks. In some cases, a collared wolf was perhaps illegally killed because of the website showing its location publicly.

The compensation the Ministry of Agriculture and Forestry of Finland provides for a highly certified dog used in hunting, such as for moose or brown bears, may be even higher than the expenses of collaring a wolf (ca. 10 000 euros, I. Kojola unpublished data). When costs and effects are considered, the website does not prevent dog attacks; it appears likely that the website did protect some dogs or increase the prevention of some attacks. It is notable that people usually form strong emotional bonds to their dogs (including both pet and hunting dogs), and dogs are often regarded as members of the family. Wolf attacks on dogs can result in emotional trauma (Ratamäki 2009; Lescureux and Linnell 2014; Niemi et al. 2014). Therefore, the monetary value of a dog based on different estimates, e.g., dog health and success in dog show and hunting tests (Finlex data bank 2020), does not indicate much about a dog's real value to its owners. Furthermore, losing a dog to wolves can erode the fragile tolerance of hunters for wolves (Lescureux and Linnell 2014).

Delivering information about wolf locations to the public to prevent wolf attacks on hunting dogs is a rare practice, even though wolf depredation on dogs is a well-known phenomenon everywhere unleashed hunting dogs are used within the range of wolves, e.g., Wisconsin (Olson et al. 2015a). In the USA, black bears are hunted with dogs in many states (Bump et al. 2013), and wolf depredation on dogs is a problem, as in Finland and Scandinavia. Solutions include sharing information with hunters about wolf caution areas (Wisconsin Department of Natural Resources 2020).

Showing wolf locations to hunters on publicly accessible websites has only been used in Finland, Sweden and Norway. In Finland, the mean proportion of wolf territories with collared wolves is approximately 25%. Wolf attacks on hunting dogs are much less frequent in western Finland than in our study area in eastern Finland (Kojola et al. unpublished data), where approximately half of the Finnish territories are located (Kojola et al. 2018). One reason for the higher risk might be lower ungulate biomass in eastern territories than in the other territories (Kojola et al. unpublished data). The likely reason almost all territories with collared wolves are situated in eastern Finland is land ownership. Collaring requires that a landowner provide a permit, and only land areas owned by the state or forest companies are large enough for capturing wolves. Such areas are highly concentrated in eastern Finland (Natural Resources Institute Finland 2019b). Negative attitudes towards wolves and wolf research are not rare (Bisi et al. 2010), and if even a few private landowners within wolf territory do not accept collaring, then it is often impossible to conduct.

Technical improvements to collar functions are desired by hunters. The requirement of having seven consecutive locations before the locations are downloadable to the webpage means that even when all consecutive attempts to locate a wolf are successful, the time passed since the last location can be seven hours. Online connections to wolves might help hunters protect their dogs more efficiently but might also encourage some people to try to illegally kill the wolves. The 5×5 km accuracy of the currently available data on the public website is coarse enough to maintain the risk at a relatively low rate, at least during the snow-free season (normally starting in November). Although Suutarinen and Kojola (2017) reported that illegal killing was the main cause of mortality of collared wolves (40%), the number of possibly illegally killed wolves in this study was relatively low (15%). Collars did not appear to affect poaching risk because estimated poaching rates based on the fates of collared wolves were highly correlated with fluctuations in the Finnish wolf population (Suutarinen and Kojola 2017).

There is little evidence that wolves actively seek dogs, and the attacks appear to be more opportunistic in nature (Paquet 1991); however, it is possible to predict the probability of an attack based on non-wolf-related factors such as landscape and the severity of the previous year winter and wolf-dependent factors such as pack size (Edge et al. 2011; Olson et al. 2014). More research is needed because attacks are still not well documented in the scientific literature (Butler et al. 2015).

Although the number of attacks in Finland is not high, from 2010–2017, wolves killed an average of 38 dogs per year, and it is important to note that a much higher number of hunting dogs are potential targets of a wolf attack, especially within the wolf territories. On some occasions, the risk of wolf attacks on dogs has led hunters to stop hunting entirely (Bisi et al. 2007). Hunters may sometimes skip the training and testing of hunting dogs owing to the risk. Training hunting dogs is important for hunters who selectively breed hunting dogs. On the other hand, Finland has to protect its endangered wolf population, and the authorities have an ethical and professional responsibility to manage wildlife populations as best as they can and carefully consider the best long-term solutions, e.g., changing people's attitudes (Bisi et al. 2010), to accomplish this (Wallach et al. 2015).

Conclusions

Our study reveals that knowing where wolves occur decreases the risk of attacks on hunting dogs. Although the measure is expensive and there are many reservations, the website was useful for hunting dog owners and might mitigate the conflict between humans and wolves. Although public information would decrease the risk of attacks, it does not provide full protection for dogs and may in some cases increase the risk of illegally killing of wolves. The most remarkable benefit of this kind of service to conservation of the wolf population might be its message to the public, a demonstration that management is not overlooking hunters' concern about wolf attacks on their dogs.

Acknowledgements

We are grateful to Antero Hakala, Leo Korhonen, Esa Leinonen, Reima Ovaskainen and Seppo Ronkainen for collaring the wolves, and to Ministry of Agriculture and Forestry of Finland for funding the collaring.

The authors have declared that no competing interests exist.

The authors have no support to report.

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